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REMOVAL SITE EVALUATION INSTALLATION OF THE TELEPHONE POLES ANALYTICAL FACILITY UPGRADE PROJECT FEBRUARY 25, 1991

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REMOVAL SITE EVALUATION

INSTALLATION OF THE TELEPHONE POLES

ANALYTICAL FACILITY UPGRADE PROJECT

Feed Materials Production Center
U. S. Department of Energy

February 25, 1991

Introduction

In support of the Analytical Facility Upgrade two new ten-plex facilities and duo-plex facilities will be installed. These facilities (to be located just southeast of the Laboratory) will be used by personnel who must be relocated during the Analytical Facility Upgrade project. Phone service to the new Analytical Facility and trailer complex is required. To accomplish this task, new telephone poles must be installed from the southwest corner Administration Building to the northeast corner of the Analytical Facility and to the new trailer complex.

Excavation for this project involves removal of approximately five cubic yards of soil. A motor driven auger will be used to dig a total of seven holes (two feet in diameter by six feet deep). The poles are 35 feet tall and shall be set at a six foot underground depth. The first pole shall be located just south of the Administration Building Frame room. Additional poles shall be installed at 150 foot intervals extending to the northeast corner of the new Analytical Facility. The poles shall be installed using a pole installation truck.

This Removal Site Evaluation (RSE) has been completed by the Department of Energy (DOE) under authorities delegated by Executive Order 12580 under Section 104 of CERCLA and is consistent with Section 300.410 of the National Oil and Hazardous Substance Pollution Contingency Plan (NCP). This RSE addresses the construction activities related to the installation of telephone poles at the FMPC and has been completed to support the decision as to whether the present conditions warrant a removal action. In order to support the decision concerning a removal action based on present conditions, a risk analysis was conducted (Attachment 3) to characterize the potential risks experienced by two Reasonable Maximum Exposure (RME) individuals. The two RME individuals are identified under Exposure Scenario #1 and #2. Exposure Scenario #1 analyzes the doses and risks associated with an individual walking past the contaminated areas on a daily basis. Exposure Scenario #2 evaluates the doses and risks associated with a worker installing the proposed telephone poles. The exposure to this individual occurs from two pathways:

1) The external radiation pathway resulting from work being performed in the contaminated region.

2) The inhalation radiation pathway resulting from breathing resuspended dust which is laden with radionuclides.

Source Term

Historical records and aerial photograph reviews of the project work area did not reveal any known prior use for the project area. There is no reason to believe any production related operations, including storage, treatment or disposal activities were performed which may have contributed to a release of hazardous waste constituents to the environment at this project area. The site characterization data discussed in the following sections directly support this position.

Total uranium and total thorium, assumed to be represented by a natural isotopic activity distribution, are the only radionuclides of concern. In order to simplify the calculations and provide conservative dose and risk estimates, the maximum total uranium and thorium values were used.

431 parts per million = Concentration at Sample Point 1 for uranium.

88 parts per million = Concentration at Sample Point 2 for thorium.

Assuming a natural activity distribution would correspond to the following activities:

Total uranium = 187.5 pCi/g

U-238 = 140.5 pCi/g

U-235 = 6.5 pCi/g

U-234 = 140.5 pCi/g

Although a natural isotopic distribution is assumed for the uranium isotopes, the uranium contamination is assumed to be of NORMAL content. This means the only daughters which are included in the dose and risk calculations of the processed uranium are the immediate, short-lived thorium-234 and protactinium-234.

Total thorium represents all thorium-232

Th-232 = 9.60 pCi/g

Th-228 = 9.60 pCi/g (Secular Equilibrium with thorium-232)

As part of the site characterization activities, surface and subsurface soil sampling was performed along the proposed excavation route. The location and analytical results of each sample are provided as Attachment 1 and 2 respectively.

Evaluation of the Magnitude of the Potential Threat

As indicated by these analytical results, 14 individual samples show concentrations of uranium or thorium above Category 1 requirements as defined in FMPC Site Procedure 720 (see Table 1). Additionally, the TCLP analysis of 17 surface samples (completed on 12/21/90) indicated RCRA constituents are below regulatory limits (see Table 2). A summary of the sample results listed in Table 1 and 2 is as follows:

a. 12 of the 17 surface soil samples taken for Total Uranium content are over 50 ppm (35 pCi/g).

b. 1 of the 17 surface soil samples (Sample point 3-0) taken for Total Thorium content is over 46 ppm (10 pCi/g).

c. 1 of the 17 one foot depth soil samples (Sample Point 17-1) taken for Total Uranium content is over 50 ppm.

d. None of the one foot depth soil samples taken for Total Thorium content are over 50 ppm.

e. None of the soil samples taken for TCLP analysis are above the regulatory level.

f. Sample point #17 for Total Uranium shows an inversion: The surface value is at 18 ppm whereas the one foot reading is 57 ppm.

The acceptable residual concentrations in surface soil is assumed to be 35 pCi/g (approximately 50 ppm) total uranium and 10 pCi/g (approximately 46 ppm) total thorium for for the FMPC, prior to specification of final clean-up criteria under the RI/FS. These concentrations were developed from the Nuclear Regulatory Commission (NRC) Branch Technical Position, "Disposal or On-Site Storage of Residual Thorium or Uranium (Either as Natural Ores or Without Daughters Present) From Past Operations" (1981) and has been adapted from numerous sites throughout the United States.

Dose and risk was estimated in two exposure scenarios for the identified maximum source locations. Exposure Scenario #1 was identified by an external radiation pathway which occurs as the receptor (an RME individual) walks past the contaminated areas each day. Exposure Scenario #2 was identified by the worker who performs the excavation activities along with the installation of the telephone poles.

Total risk for Exposure Scenario #1 is shown below:

$$\text{Total risk} = 8.5\times10^{-7}$$

This value represents the potential annual risk to an individual walking past the idealized contaminated region on a daily work basis.

Similarly, the total risk for Exposure Scenario #2 is shown below:

$$\text{Total Risk} = 1.53\times10^{-7}$$

These risks are based on several assumptions which greatly exaggerate the doses and associated risks. The assumptions are outlined below:

1) A constant homogeneous source distribution.

2) Conservative, hypothetical exposure scenarios.

3) A uniform source distribution.

4) A conservative dust resuspension factor.

Even considering the above assumptions, the doses estimated in this assessment can be considered insignificant. The EPA and NRC have proposed BRC (Below Regulatory Concern) dose levels of between 5 to 10 mrem per year, committed effective dose equivalent. As a result, the estimated risks are in the range of proposed "diminis levels" (Travis, 1989).

In order to significantly reduce the potential threat of contaminate releases during relocation of the soil, control measures will be administered as follows:

1. During excavation, soil and boxes will be placed on plastic to prevent possible migration.

2. In the event that the soil has dried to the point where dusting is possible, manual re-wetting of the soil will be performed.

3. The volume of soil removed from zero to twelve inches shall be placed in metal boxes to facilitate proper dispositioning (pending RCRA determination from the existing sample data). Soil below the one foot depth will be dispositioned per FMPC Site Policy and Procedure #FMPC-720, "Control of Construction Waste".

4. Excavations for poles shall not be left open, poles will be placed immediately upon completion of the excavation. Therefore, the possibility of run on and run off water will not occur.
5. Dispositioning/handling of the soil shall be performed during non-peak personnel traffic times and/or by using an appropriate personnel detour route away from the area.

6. Final soil disposition shall be in accordance with radiological guidelines specified in Site Policy and Procedure #FMPC-720, "Control of Construction Waste;" and per the specific requirements noted within this RSE document; as well as consistent with site zoning procedures.

Based on the attached data, only Sample point #17 exceeds the acceptable residual concentration at a one foot depth. Telephone pole installation is not planned in the area where this sample was taken. However, telephone cabling is to be inserted with minimal soil disturbance in this area. This activity is not expected to result in a substantial threat of release of hazardous waste constituents to the environment.

Assessment of the Need for Removal Action

Consistent with Section 40 CFR 300.410 of the National Contingency Plan, the Department of Energy shall determine the appropriateness of a removal action. Section 40 CFR 300.415 (b) (2) of the National Contingency Plan defines eight factors which should be considered in determining the appropriateness of a removal action. Three of these factors (listed below) are specifically applicable to this assessment:

i. Actual or potential exposure to nearby human populations, animals or the food chain from hazardous substances or pollutants or contaminants.

iv. High levels of hazardous substances, pollutants or contaminants in soils largely at or near the surface, that may migrate.

v. Weather conditions that may cause hazardous substances, pollutants or contaminants to migrate or be released.

These factors are considered appropriate as a result of the potential exposure to, or release of hazardous waste constituents, pollutants or contaminants from locations where the telephone poles are to be installed.

Appropriateness of a Response

If it is determined that a response action is appropriate due to the migrating potential of disturbed contaminants and nature of the excavation activities involved in the telecommunications project, a removal action may be required to address the existing situation.

If a planning period of less than six months exists prior to initiation of a response action, DOE will issue an Action Memorandum. The Action Memorandum will describe the selected response and provide supporting documentation for the decision.
If it is determined that there is a planning period greater than six months before a response is initiated, DOE will issue an Engineering Evaluation/Cost Analysis (EE/CA) Approval Memorandum. This memorandum is to be used for documenting the threat to public health and the environment and for evaluating viable alternative response actions. It will also serve as a decision document to be included in the Administrative Record.

Based on the evaluation of all of the above factors, it has been determined that existing controls for the planned action are adequate and a removal action is not required.

Removal Site Evaluation
Installation of the Telephone Poles
Analytical Facility Upgrade Project

Attachment 2

Table 1

THORIUM AND URANIUM ANALYSIS OF SOIL SAMPLES

Sample Point	Depth	Analysis	Result	Level of Concentration
#1-0	surface	Total U	431 ppm	Category 3
#1-0	surface	Total Th	24 ppm	Category 1
#2-0	surface	Total U	432 ppm	Category 3
#2-0	surface	Total Th	37 ppm	Category 1
#3-0	surface	Total U	328 ppm	Category 3
#3-0	surface	Total Th	88 ppm	Category 2
#4-0	surface	Total U	267 ppm	Category 3
#4-0	surface	Total Th	18 ppm	Category 1
#5-0	surface	Total U	278 ppm	Category 3
#5-0	surface	Total Th	18 ppm	Category 1
#6-0	surface	Total U	201 ppm	Category 3
#6-0	surface	Total Th	18 ppm	Category 1
#7-0	surface	Total U	132 ppm	Category 2
#7-0	surface	Total Th	18 ppm	Category 1
#8-0	surface	Total U	34 ppm	Category 1
#8-0	surface	Total Th	18 ppm	Category 1
#9-0	surface	Total U	46 ppm	Category 1
#9-0	surface	Total Th	18 ppm	Category 1
#10-0	surface	Total U	30 ppm	Category 1
#10-0	surface	Total Th	18 ppm	Category 1
#11-0	surface	Total U	19 ppm	Category 1
#11-0	surface	Total Th	18 ppm	Category 1
#12-0	surface	Total U	61 ppm	Category 2
#12-0	surface	Total Th	18 ppm	Category 1
#13-0	surface	Total U	64 ppm	Category 2
#13-0	surface	Total Th	18 ppm	Category 1

Footnotes:

A. Category 1 soil is less than or equal to 35 pCi/g. (35 pCi/g equals 50 ppm)

B. Category 2 soil is greater than 35 pCi/g but less than or equal to 100 pCi/g. (100 pCi/g equals 150 ppm)

C. Category 3 soil is greater than 100 pCi/g.

Removal Site Evaluation
Installation of the Telephone Poles
Analytical Facility Upgrade Project

Attachment 2

Table 1 (con't)

THORIUM AND URANIUM ANALYSIS OF SOIL SAMPLES

#14-0	surface	Total U	56 ppm	Category 2
#14-0	surface	Total Th	18 ppm	Category 1
#15-0	surface	Total U	120 ppm	Category 2
#15-0	surface	Total Th	18 ppm	Category 1
#16-0	surface	Total U	72 ppm	Category 2
#16-0	surface	Total Th	18 ppm	Category 1
#17-0	surface	Total U	20 ppm	Category 1
#17-0	surface	Total Th	18 ppm	Category 1
#1-1	1 foot	Total U	45 ppm	Category 1
#1-1	1 foot	Total Th	18 ppm	Category 1
#2-1	1 foot	Total U	49 ppm	Category 1
#2-1	1 foot	Total Th	18 ppm	Category 1
#3-1	1 foot	Total U	16 ppm	Category 1
#3-1	1 foot	Total Th	18 ppm	Category 1
#4-1	1 foot	Total U	12 ppm	Category 1
#4-1	1 foot	Total Th	18 ppm	Category 1
#5-1	1 foot	Total U	12 ppm	Category 1
#5-1	1 foot	Total Th	18 ppm	Category 1
#6-1	1 foot	Total U	27 ppm	Category 1
#6-1	1 foot	Total Th	18 ppm	Category 1
#7-1	1 foot	Total U	11 ppm	Category 1
#7-1	1 foot	Total Th	18 ppm	Category 1
#8-1	1 foot	Total U	11 ppm	Category 1
#8-1	1 foot	Total Th	18 ppm	Category 1
#9-1	1 foot	Total U	27 ppm	Category 1
#9-1	1 foot	Total Th	18 ppm	Category 1

Footnotes:

A. Category 1 soil is less than or equal to 35 pCi/g. (35 pCi/g equals 50 ppm)

B. Category 2 soil is greater than 35 pCi/g but less than or equal to 100 pCi/g. (100 pCi/g equals 150 ppm)

C. Category 3 soil is greater than 100 pCi/g.

Removal Site Evaluation
Installation of the Telephone Poles
Analytical Facility Upgrade Project

Attachment 2

Table 1 (con't)

THORIUM AND URANIUM ANALYSIS OF SOIL SAMPLES

#10-1	1 foot	Total U	21 ppm	Category 1
#10-1	1 foot	Total Th	18 ppm	Category 1
#11-1	1 foot	Total U	22 ppm	Category 1
#11-1	1 foot	Total Th	18 ppm	Category 1
#12-1	1 foot	Total U	17 ppm	Category 1
#12-1	1 foot	Total Th	18 ppm	Category 1
#13-1	1 foot	Total U	29 ppm	Category 1
#13-1	1 foot	Total Th	18 ppm	Category 1
#14-1	1 foot	Total U	18 ppm	Category 1
#14-1	1 foot	Total Th	18 ppm	Category 1
#15-1	1 foot	Total U	11 ppm	Category 1
#15-1	1 foot	Total Th	18 ppm	Category 1
#16-1	1 foot	Total U	29 ppm	Category 1
#16-1	1 foot	Total Th	18 ppm	Category 1
#17-1	1 foot	Total U	57 ppm	Category 2
#17-1	1 foot	Total Th	18 ppm	Category 1

TABLE 2

TCLP ANALYSIS OF SOIL SAMPLES

	Regulatory Level: mg/l	Sample Point 1	Sample Point 2	Sample Point 3	Sample Point 4	Sample Point 5
Arsenic	5.0	<0.100	<0.100	<0.005	<0.005	<0.055
Barium	100.0	0.606	0.571	0.616	0.480	0.631
Cadmium	1.0	<0.005	<0.005	<0.006	<0.005	<0.005
Chromium	5.0	<0.008	<0.008	<0.008	<0.008	<0.008
Lead	5.0	<0.030	<0.030	<0.177	<0.030	<0.030
Mercury	0.2	<0.002	<0.002	<0.002	<0.002	<0.002
Selenium	1.0	<0.010	<0.010	<0.010	<0.010	<0.010
Silver	5.0	<0.005	<0.005	<0.005	<0.005	<0.005

Footnotes:

A. Category 1 soil is less than or equal to 35 pCi/g. (35 pCi/g equals 50 ppm)

B. Category 2 soil is greater than 35 pCi/g but less than or equal to 100 pCi/g. (100 pCi/g equals 150 ppm)

C. Category 3 soil is greater than 100 pCi/g.

Removal Site Evaluation
Installation of the Telephone Poles
Analytical Facility Upgrade Project

Attachment 2

Table 2 (con't)

TCLP ANALYSIS OF SOIL SAMPLES

	Regulatory Level: mg/l	Sample Point 6	Sample Point 7	Sample Point 8	Sample Point 9	Sample Point 10
Arsenic	5.0	<0.005	<0.005	<0.005	<0.005	<0.005
Barium	100.0	0.655	0.586	0.592	0.714	0.710
Cadmium	1.0	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium	5.0	<0.008	<0.008	<0.008	<0.008	<0.008
Lead	5.0	<0.030	<0.030	<0.030	<0.030	<0.030
Mercury	0.2	<0.002	<0.002	<0.002	<0.002	<0.002
Selenium	1.0	<0.010	<0.025	<0.010	<0.010	<0.010
Silver	5.0	<0.005	<0.005	<0.005	<0.005	<0.005

	Regulatory Level: mg/l	Sample Point 11	Sample Point 12	Sample Point 13	Sample Point 14	Sample Point 15
Arsenic	5.0	<0.005	<0.005	<0.005	<0.005	<0.005
Barium	100.0	0.740	0.738	0.750	0.614	1.00
Cadmium	1.0	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium	5.0	<0.008	<0.008	<0.008	<0.008	<0.008
Lead	5.0	<0.030	<0.030	<0.030	<0.030	<0.030
Mercury	0.2	<0.002	<0.002	<0.002	<0.002	<0.002
Selenium	1.0	<0.025	<0.025	<0.025	<0.025	<0.025
Silver	5.0	<0.005	<0.005	<0.005	<0.005	<0.005

	Regulatory Level: mg/l	Sample Point 16	Sample Point 17
Arsenic	5.0	<0.005	<0.005
Barium	100.0	0.902	0.715
Cadmium	1.0	<0.005	<0.005
Chromium	5.0	<0.008	<0.008
Lead	5.0	<0.030	<0.030
Mercury	0.2	<0.002	<0.002
Selenium	1.0	<0.025	<0.025
Silver	5.0	<0.005	<0.005

ATTACHMENT 3

ESTIMATION OF POTENTIAL DOSES AND RISKS ASSOCIATED WITH THE INSTALLATION OF TELEPHONE POLES ALONG THE ROUTE FROM THE ADMINISTRATION BUILDING TO THE NEW ANALYTICAL FACILITY

INTRODUCTION

This assessment will characterize the doses and risks to two Reasonable Maximum Exposure (RME) individuals as identified under Exposure Scenarios (1) and (2) below:

(1) Worker who walks past the contaminated areas (associated with the telephone pole route) on a daily basis over an annual time frame of exposure duration.

(2) Worker who prepares the contaminated regions for installing the telephone poles. This individual is assumed to work in the contaminated area on a daily basis, five days per week, for a total of one month.

The format for this investigation will consist of the following components: 1) source characterization, 2) exposure scenarios and their associated parameters, 3) exposure pathways and their methodology, and 4) dose and risk results for each exposure scenario.

SOURCE CHARACTERIZATION

The radioactivity sources for this investigation are assumed to be uniformly and homogeneously distributed throughout the contaminated zone, as represented by the maximum observed concentrations of total uranium and thorium in Attachment 1. In addition, it is assumed that the uniform distribution of radionuclides along the telephone cable route are within what can be considered an infinite or semi-infinite region. The volume of contamination is assumed to be uniformly distributed to an infinite depth as well. As a result of these assumptions, the resulting dose distribution can be assumed to be uniform within the body (Gilbert, 1989). Finally by utilizing these idealized assumptions, dose conversion factors (DCFs) relating an effective dose equivalent rate to a radionuclide concentration can be established.

The external radiation pathway is primarily controlled by gamma-ray radiation. Gamma radiation is the primary radiation of concern for the external radiation pathway because it is sufficiently penetrating to represent a dose at considerable distances. The DCFs for ground contamination were developed based on exposure at a distance of one meter above the ground. These DCFs represent the annual effective dose equivalent from exposure to external radiation.

The radiation dose from inhalation has been extensively evaluated by the International Radiation Protection association in its Publication 30 (ICRP, 1979-1982). Dose equivalents in organs and tissues of the body are calculated with models that describe first the entrance of materials into the body and then the deposition and later retention of the radionuclides in the bodily organs. Dose equivalents estimate the energy deposition of the radionuclides in the tissues of the body (ICRP, 1979-1982). Dose conversion factors for inhalation represent committed effective dose equivalents per unit intake of a radionuclide.

Attachment 1 of the RSE identifies a map of the proposed telephone pole route. Table 1 of Attachment 2 identifies the sample points for total uranium and thorium which are located along the proposed route. Total uranium and thorium, assumed to be represented by a natural isotopic activity distribution, are the only radionuclides of concern. In order to simplify the calculations, as well as provide conservative dose and risk estimates, the maximum total uranium and thorium values were used.

431 parts per million = Concentration at Sample point (1) for Uranium.

88 parts per million = Concentration at Sample point (2) for Thorium.

Assuming a natural activity distribution would correspond to the following activities:

Total Uranium = 293.5 pCi/g

U-238 = 140.5 pCi/g

U-235 = 6.5 pCi/g

U-234 = 140.5 pCi/g

Although a natural isotopic distribution is assumed for the uranium isotopes, the uranium contamination is assumed to be NORMAL in content, meaning that the uranium has been processed and the only daughters which are included in the dose and risk calculations are the immediate, short-lived daughters, which are thorium-234 and Protactinium-234.

Mass of Total Thorium Represents All Thorium-232

Th-232 = 9.60 pCi/g

Th-228 = 9.60 pCi/g (Secular Equilibrium with Thorium-232)

EXPOSURE SCENARIO AND PARAMETERS

The two exposure scenarios evaluated in this assessment are identified in items (1) and (2) of the introduction. The first exposure scenario is the exposure to a worker who walks through the contaminated areas on a daily basis. The second exposure scenario evaluates the exposure to the worker who installs the telephone poles. In addition to an external radiation dose, the installation of the telephone poles is assumed to result in the resuspension of dust during excavation activities which can also result in a potential dose to the RME individual.

The first exposure scenario detailing the worker who walks through the contaminated areas on a regular basis is defined by the following annual exposure parameter:

EF = Exposure Factor, 0.0286
(Based on a one hour exposure each day, 5 days each week, and 50 weeks each year.)

There are several source term parameters that function to characterize the dose to this RME individual of exposure scenario number (1). These source term parameters are components of the direct (external) radiation pathway.

FA_1 = Area Factor, 1.
(Based on the assumptions identified in the source term characterization. The subscript (1) represents the external radiation pathway.)

FS = Shape Factor, 1.
(Based on a circular and infinite medium).

The parameters identified above for exposure scenario (1) relate to the external radiation pathway. The external radiation pathway is the only pathway evaluated under exposure scenario number (1) since it represents the only potentially significant pathway of concern. A more detailed description of the external radiation pathway will be given in the following section.

The second exposure scenario, characterizing the RME individual who will be performing the installation of the telephone poles, is composed of two pathways: external radiation and inhalation of resuspended dust. The inhalation of resuspended dust becomes potentially significant where excavation of contaminated soil occurs.

The exposure and source term parameters for the external radiation and inhalation pathways are as follows:

EF = 0.0197 (Based on a limited exposure duration of 8 hours, five days each week for a total of 4.3 weeks.)

Bulk Density = Soil default value of 1.8 g/cm^3.

$FA_2 = 1$, $FA_2 = A^{1/2}/(A^{1/2}+DL)$. Determined to be 0.81, see calculations in the Exposure Pathways and Methodology Section.

A = Area of Contamination. DL = Dilution length, default value of 3 meters is typically used. The subscript (2) represents the inhalation pathway.

$FCD_{i2} = T(t)/dm$ For $Cd(t) + T(t) < dm$.

Where $Cd(t)$ = Uncontaminated cover depth at time t (0).
$T(t)$ = Contaminated zone thickness at time t, 0.1 meters.
dm = Mixing depth default of 0.15.

FI = Inhalation Rate, 8400 m^3/yr.

EXPOSURE PATHWAYS AND METHODOLOGY

The direct radiation pathway is shown in Equation (1) below:

DOSE (mrem/yr) = DCF_{i1} x Bulk Density x Source Conc. x EF x FA_1 x FS (1)

DCF_{i1} = (mrem/yr)/(pCi/cm^3) representing the annual effective dose equivalent from exposure to external radiation. See Table 3-1 for the specific values.

Bulk Density of soil with a default value of 1.8 g/cm^3.

Source Term = Picocuries/Gram of Soil for the i^{th} radionuclide.
Use the radionuclide specific values on page 3.

FS = Shape Factor, 1. The shape factor corrects for a noncircular shape area factor.

FA_1 = Area Factor, 1. The area factor represents a circular-area-equivalent contaminated zone. A more detailed analysis can be found in DOE, 1989.

EF = Occupancy and Exposure Factor.
0.0286 = Exposure Scenario #1
0.0197 = Exposure Scenario #2

The inhalation of resuspended dust pathway is shown in Equation (2) below:

DOSE (mrem/yr) = ASR x FA_2 x $FCD_{i2}(t)$ x EF x FI_2 x Source Term x DCF_{i2} (2)

ASR = Air-to-Soil resuspension factor, 2 x10^{-4} g/m^3 typically used value (USDOE, 1989).

FA_2 = Area Factor for the inhalation pathway which is identified by the subscript number 2.

*$FA_2 = A^{1/2}/(A^{1/2} + DL) = 4.80^{1/2}/(4.80^{1/2} + 3) = 0.81$
Where DL = Dilution length, default value of 3 meters.
(USDOE, 1989)

$FCD_{i2}(t)$ = Cover and Depth factor, 0.67. The cover and depth factor represents the fraction of resuspended soil particles at the ground surface that are contaminated. It is calculated by assuming that the mixing of the soil will occur within a layer of thickness d_m at the surface (USDOE, 1989). The subsript (2) represents the inhalation pathway.

The term $C_d(t)$ represents the uncontaminated cover depth (meters) at time "t". The T(t) term represents the contaminated thickness depth (meters) at time "t".

EF = Exposure Factor, (0.0197 for exposure Scenario #2).

FI = Average adult breathing rate, 8400 m^3/yr.

Source Term = Picocuries per Gram of soil for the i^{th} radionuclide. See page 3 for radionuclide specific concentrations.

DCF_{i2} = Annual committed Effective Dose Equivalent from a one time exposure for 50 years of internal intake of i^{th} radionuclide (USDOE, 1989). See Table 3-3 for specific DCFs.

* Contaminated zone area based on excavation of 4.8 m^2.

DOSE AND RISK RESULTS

The purpose of this section is to bring together the source term characterization, the exposure scenario descriptions, and the pathway analysis methodology and then estimate the resulting doses and risks. There were two exposure scenarios identified in the introduction, numbered as (1) and (2). Over these two exposure scenarios doses and risks will be estimated for the telephone pole region of contamination. The results will appear as follows:

Exposure Scenario #1

General Equation for External Radiation Pathway

$$\text{DOSE} = DCF_{i1} \times \text{Bulk Density} \times \text{Source Term} \times EF \times FA_1 \times FS$$

Table 3-1: Doses and Risks for the External Radiation Pathway of Exposure Scenario #1

Radionuclide	DCF_{i1} (mrem/yr)/(pCi/cm^3)	Dose (mrem/yr)	Risk/yr*
U-238+D	6.97×10^{-2}	5.0×10^{-1}	1.0×10^{-7}
U-235+D	4.9×10^{-1}	1.6×10^{-1}	3.2×10^{-8}
U-234	6.97×10^{-4}	5.0×10^{-3}	1.0×10^{-9}
Total U	-	7.1×10^{-1}	1.3×10^{-7}
Th-232+D	6.04×10^{-4}	3.0×10^{-4}	6.0×10^{-11}
Th-228+D	7.36	3.6	7.2×10^{-7}
Total Th	-	3.6003	7.2×10^{-7}

Total Risk = $1.3 \times 10^{-7} + 7.2 \times 10^{-7} = 8.5 \times 10^{-7}$

*Based on using BEIR III Risk coefficient of 2×10^{-7} Risk/mrem.

+D = Aggregated Dose Conversion Factors for Intake of Principal Radionuclides plus Radionuclides of Associated decay chain in secular equilibrium.

Exposure Scenario #2

Table 3-2: Doses and Risks for the External Radiation Pathway for Exposure Scenario #2

Dose = DCF_{i1} x Bulk Density x Source Term x EF x FA_1 x FS

Radionuclide	DCF_{i1} (mrem/yr)/(pCi/cm^3)	Dose (mrem/yr)	Risk/yr
U-238+D	6.97×10^{-2}	3.0×10^{-1}	6.0×10^{-8}
U-238+D	4.9×10^{-1}	1.0×10^{-1}	2.0×10^{-8}
U-234	6.97×10^{-4}	3.0×10^{-3}	6.0×10^{-10}
Total U	-	4.03×10^{-1}	8.06×10^{-8}
Th-232+D	6.04×10^{-4}	2.0×10^{-4}	4.0×10^{-11}
Th-228+D	7.36	2.5	5.0×10^{-7}
Total Th	-	2.5	5.0×10^{-7}

Sum of External Risk = $8.06 \times 10^{-8} + 5.0 \times 10^{-7} = 5.8 \times 10^{-7}$

• Based on BEIR III Risk Coefficient of 2×10^{-7} risk/mrem

+D = Aggregated Dose Conversion Factors for Intake of Principal Radionuclide Plus Radionuclides of Associated decay chain in secular equilibrium.

Exposure Scenario #2

General Equation for the Inhalation of Resuspended Dust Pathway

$$\text{Dose} = DCF_{i2} \times ASR \times FA_2 \times \text{Source Term} \times FCD_{i2} \times EF \times FI_2$$

Table 3-3: Doses and Risks from the Inhalation of Dust Pathway for Exposure Scenario #2

Radionuclide	DCF_{i2} (mrem/pCi)	Dose (mrem/yr)	Risk/yr
U-238+D	1.2×10^{-1}	1.5×10^{-1}	3.0×10^{-8}
U-235+D	1.2×10^{-1}	7.1×10^{-3}	1.0×10^{-10}
U-234	1.3×10^{-1}	1.7×10^{-1}	4.0×10^{-8}
Total U	-	3.27×10^{-1}	7.01×10^{-8}
Th-232+D	1.1	9.6×10^{-2}	2.0×10^{-8}
Th-228+D	3.1×10^{-1}	2.7×10^{-2}	5.0×10^{-9}
Total Th	-	1.23×10^{-1}	2.5×10^{-8}

Sum of Inhalation Risk = $2.5 \times 10^{-8} + 7.01 \times 10^{-8} = 9.51 \times 10^{-8}$

TOTAL RISK (Both Pathways) = $9.51 \times 10^{-8} + 5.8 \times 10^{-8} = 1.53 \times 10^{-7}$

• Based on using BEIR III Risk Coefficient of 2×10^{-7} risk/mrem.

+D = Aggregated Dose Conversion Factors for Intake of Principal Radionuclide Plus Radionuclides of Associated decay chain in secular equilibrium.

SUMMARY/DISCUSSION OF RESULTS

Dose and risks were estimated for two exposure scenarios for the maximum identified source locations. Exposure scenario number (1) was identified by an external radiation pathway which occurs as the receptor, an RME individual, walks past the contaminated areas each day. Exposure scenario number (2) was identified by the worker who performs the excavation activities along with the installation of the telephone poles.

The total risk for exposure scenario number (1) is shown below:

$$\text{Total Risk} = 8.5 \times 10^{-7}$$

This value represents the potential annual risk to an individual walking past the idealized contaminated region on a daily work basis.

Similarly, the total risk for exposure scenario number (2) is shown below:

This value represents the potential risk to the individual installing the telephone poles.

$$\text{Total Risk} = 1.53 \times 10^{-7}$$

These risks are based on several assumptions, outlined below, which greatly exaggerate the doses and associated risks.

1) A constant homogeneous source distribution.

2) Conservative, hypothetical exposure scenarios.

3) A uniform source distribution.

4) A conservative dust resuspension factor.

Even considering the above assumptions, the doses estimated in this assessment can be considered insignificant. The EPA and NRC have proposed BRC (Below Regulatory Concern) dose levels of between 5 to 10 mrem per year, committed effective dose equivalent. As a result, the risks estimated are in the range of proposed "diminis levels" (Travis, 1989).

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